Issued by the Colonial Office

EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

FIFTH ANNUAL REPORT 1932-33

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CONTENTS

	Page
Staff List, Leave Movements, and Staff Changes	3
Publications	4
Visitors	5
Report of the Director	6
Report of the Plant Pathologist	13
Virus Disease Investigations	13
Ad hoc Investigations	17
General	17
Report of the Entomologist	17
Report of the Soil Chemist	
General Survey and Classification	19
Special Studies of the Soil Groups	19
Manuring	22
Nitrogen-changes	23
Erosion	24
Irrigation Problems	24
Miscellaneous	24
Report of the Biochemist	
Insecticides from Local Plants	25
Fermentation of Coffee	26
Carbohydrate-Nitrogen Ratio in Coffee	27
Coffee Ash Analyses	27
Essential Oils	27
Kweme Nuts	28
Report of the Plant Physiologist	
Coffee Investigations	28
Sisal Investigations	30
Report of the Plant Geneticist	32
Coffee	32
Sisal	33
Report of the Systematic Botanist	
Herbarium	34
Exchanges	36
Field Work	37
Ornithological Work	38
Report of the Superintendent of Plantations	40
Construction and Maintenance	40
Plantations and Nurseries	42
Plant and Seed Introduction	43
Plant and Seed Distribution	43
Report of the Secretary and Librarian	44
Appendix A—Financial Statement	45
Appendix B—Periodicals	46

EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

Report for the Period 1st April, 1932, to 31st March, 1933

STAFF LIST.

Director.—W. Nowell, C.B.E., D.I.C., F.L.S.

Plant Pathologist.—H. H. Storey, M.A., Ph.D.

Entomologist.—T. W. Kirkpatrick, M.A., Dipl. Agric. (Cantab.), F.E.S.

Soil Chemist.—G. Milne, M.Sc., F.I.C.

Biochemist.—R. R. Le G. Worsley, A.R.C.S., B.Sc., Ph.D.

Plant Physiologist.—F. J. Nutman, A.R.C.S., M.Sc., D.I.C.

Plant Geneticist.—L. R. Doughty, B.Sc. (Agric.), N.D.A.

Superintendent of Plantations.—F. M. Rogers.

Secretary and Librarian.—R. E. Moreau.

Botanist.—P. J. Greenway, F. L. S.

Assistant Superintendent of Plantations.—*Vacant.*

Assistant Secretary and Librarian.—W. M. Nutter.

Engineer-Mechanic.—T. V. Greenwood.

Laboratory Assistant (Pl. Path.).—R. F. W. Nichols.

Laboratory Assistant (Soil Chem.).—W. E. Calton, B.A., Dipl. Agric.

Stenographer.—(Miss) K. Rushworth.

LEAVE MOVEMENTS DURING THE YEAR.

	Departed.	*Returned.*
Mr. T. V. Greenwood...	—	13th July, 1932.
Mr. W. M. Nutter ...	—	2nd November, 1932
Mr. R. F. W. Nichols ...	3rd May, 1932.	6th January, 1933.
Mr. K. E. Toms ...	18th May, 1932.	—
Mr. L. R. Doughty ...	9th June, 1932.	25th January, 1933.
Mr. W. E. Calton ...	13th October, 1932.	—
Dr. H. H. Storey ...	29th March, 1933.	—

CHANGES OF STAFF.

Mr. K. E. Toms, Assistant Superintendent of Plantations, has left the service of the Station to take a refresher course at the Imperial College of Tropical Agriculture, Trinidad. For reasons of economy it is not proposed to fill the vacancy.

PUBLICATIONS.

The following papers contributed to scientific journals by members of the staff of the Research Station have been treated as Station Memoirs and separates distributed :—

A Bark Disease of Coffee in East Africa. H. H. Storey, *Annals of Applied Biology*, 19, No. 2, 1932.

Vegetation of Mpwapwa, Tanganyika Territory. P. J. Greenway, *Journal of Ecology*, 21, No. 1, 1933.

The Inheritance by an Insect Vector of the Ability to Transmit a Plant Virus. H. H. Storey, *Proceedings of the Royal Society*, B, 112, 1932.

A Sulphur-deficiency Disease of the Tea Bush. H. H. Storey, *Annals of Applied Biology*, 20, Part 1, 1933.

In addition, copies of the " Proceedings of a Conference of East African Soil Chemists held at the Agricultural Research Station, Amani " in May, 1932 (Technical Conferences of the East African Dependencies Series) have been sent to those of our correspondents likely to be interested.

The undermentioned papers have been completed and are awaiting publication :—

Pleistocene Climatic Changes and the Distribution of Life in East Africa. R. E. Moreau.

On the Food of the Red-billed Oxpecker. R. E. Moreau.

A Note on the Distribution of *Gypohierax angolensis* (Gmel.), the Vulturine Fish-eagle. R. E. Moreau.

Observations on the Desert Locust in East Africa from July, 1928, to April, 1929. C. B. Williams.

Contributions to Tropical African Bird-Ecology, No. 1 : Introductory : Some General Considerations. R. E. Moreau..

A Chemical Survey of the Waters of Mount Meru, Tanganyika Territory, especially with regard to their qualities for Irrigation. D. Sturdy, W. E. Calton, and G. Milne.

* Root-systems of *Coffea arabica*. F. J. Nutman.

Experimental Studies of the Function of Insects in the Transmission of Plant Viruses. H. H. Storey.

A paper entitled " The Bearing of Insect Vectors on the Differentiation and Classification of Plant Viruses " (H. H. Storey) appeared in the Proceedings of the 2e Congrès International de Pathologie Comparée, but no separates are available for distribution by the Research Station.

VISITORS.

Oversea visitors to the Station during the year include Mr. J. P. R. Maud, M.A., Lieutenant-General Sir Aylmer Hunter-Weston, K.C.B., D.S.O., M.P., Dr. H. H. Mann, F.I.C., the late Sir Sydney Armitage-Smith, K.B.E., C.B., and Mr. F. G. Lee, Colonial Office.

Official visitors include His Excellency Sir Stewart Symes, K.C.M.G., K.B.E., D.S.O., Governor of the Tanganyika Territory ; Mr. A. H. White, O.B.E., Provincial Commissioner, Tanganyika Territory ; Mr. A. J. Wakefield, B.Sc., Acting Director of Agriculture, Tanganyika Territory ; Dr. G. B. Wallace, B.Sc., Mycologist, Tanganyika Territory ; Mr. C. Gillman, Chief Engineer of Railways, Tanganyika Territory ; Mr. L. W. Raymond, Government Chemist, Department of Agriculture, Zanzibar ; and Dr. D. Wilson, Malaria Research Officer, Medical Department, Tanganyika Territory.

There were a large number of unofficial visitors to the Station representing a wide range of scientific and agricultural interests in East Africa and elsewhere, including a large party of students on tour from the South African Universities.

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* Advance abstracts have already been circulated to contributing Governments.

REPORT OF THE DIRECTOR.

General.

The expectation of a productive year, based on the occurrence of a minimum of leave interruptions, has been realized. Definite advances have been made along many lines of investigation and, although the programme of long-range research has been followed, some important results capable of immediate application have been reached by the way, especially in relation to the coffee and sisal industries.

There is, happily, little to say this year regarding matters of organization. The laboratory supply services have functioned smoothly and without interruption, and the new road, since completion, has enabled a reliable transport service for all purposes to be maintained. Profitable sales of Cinchona bark and coffee have built up a reserve adequate to meet the small-scale financial emergencies which experience has shown must arise from time to time in an institution with a rigidly fixed appropriation to which normal expenditure is narrowly adjusted.

The only disquieting feature of the year has been the unusual number of cases of malaria affecting members of the staff or their families. These have emphasized the difficulties of dealing with cases of illness in a small and isolated community.

Coffee Investigations.

The Plant Physiologist has recently completed an intensive study of the root system of *Coffea arabica* as developed under the exceedingly varied conditions of the principal plantation districts of Tanganyika Territory and, for comparison, of two districts in Kenya. The root systems of sixty-seven trees have been exposed in vertical section and charted. Extreme variations in form and range have been revealed, and on the basis of pH data provided by the Soil Chemist it appears that a close correlation exists between root distribution and the acidity gradient of the soil profile. Where the reaction throughout the soil is neutral or nearly so the feeding roots tend to be uniformly dispersed to depths approaching ten feet. Where a mildly acid or neutral surface soil overlies an acid subsoil the roots are concentrated in this upper layer, occupying in extreme cases less than the first foot.

This observation suggests an explanation of perplexing problems of long standing regarding the behaviour of coffee in certain districts. The persistent failure extending over 30 years of the East Usambara estates, in spite of favourable climatic conditions, to realize expectations, and the more recent failures in the Rungwe district, both of which places are characterized by highly acid soil, appear capable of explanation on these lines. Confirmation is being sought by further observation and experiment. The possibilities

of amelioration would appear to depend on the availability of liberal supplies of organic manure.

These root studies have also revealed the previously unsuspected fact that the defoliation and die-back of branches which so frequently occur in the course of maturation of premature or heavy crops are accompanied by equally severe reduction of the smaller roots. This damage, moreover, appears to be permanent and may account for the known difficulty of restoring trees which have suffered from die-back.

Regarding the origin of this die-back due to "overbearing," which as indicated in previous Reports is probably the most generally serious coffee trouble in East Africa, evidence has been found that it is correlated with the exhaustion of carbohydrate reserves. Arrangements have been made for this theory of its nature to be adequately tested during the present crop season.

As reported by the Biochemist, efforts to throw light on the nature of the trouble by determining carbohydrate-nitrogen ratios and by investigating the possibility of copper deficiency have given negative results. The beneficial effect of copper sprays in reducing defoliation remains unexplained.

Fermentation.—Further work on fermentation confirms the view that this process is no more than a somewhat primitive method of scouring the beans after pulping and has no effect on quality, apart from the possibility which exists of causing deterioration through unskilful handling. This view is much strengthened by reports communicated by the Tanganyika Department on samples prepared by the Raoeng pulper, in which the beans are pulped and mechanically scoured in one operation.

The same trials indicate, however, that significant differences may be produced by the nature of the drying process. Investigation will now be directed to the thermal death-point of the embryo and to temperature effects on the enzyme action which presumably takes place.

Liquoring.—There is a persistent demand from coffee growers for information regarding the factors which influence liquoring quality and give rise to the wide divergencies of price on the London market. The insuperable difficulty of a scientific investigation lies in the fact that liquoring quality has evaded all attempts at determination by other means than the personal judgment of the expert. Recognizing perforce this limitation, arrangements have been made with the Imperial Institute to submit series of samples, selected with the co-operation of the Departments of Agriculture to represent the whole range of East African production, to expert estimation, the process being standardized to the extent that the human element will allow. It is hoped by this means to establish some correlation of quality with the known conditions under which the samples are produced. The first trials made under this system, representing the coffees of 1932, were unsatisfactory owing to a lack

of precision due to the merely qualitative nature of the reports. As a result of further discussion arrangements have now been made for the reports to be placed on a quantitative basis by the adoption of a scale of marks.

Vegetative propagation.—Trials of the grafting of *arabica* scions on to stocks of different species and of various ages have been continued. Some of the earlier grafts have now reached bearing age. Seedling grafting gives promise of being a successful and convenient method where suitable nursery facilities can be provided.

Coffea liberica has so far given outstanding results as a stock under the local conditions but it is too early to make a definite pronouncement. Results from the use of cuttings do not offer much encouragement.

Miscellaneous.—Observation of the effects of different degrees of artificial shade has been interrupted by difficulties experienced in maintaining both the trees themselves and the fabric shade. These have now been met and the plots restored to good condition. No great importance is attached to the manurial experiments on old trees at Kwamkoro, but the results will provide evidence essential for the full elucidation of the problem of the comparative failure of coffee in this district.

Coffee Experiment Station.—The establishment of a coffee experiment station at Moshi, for which the plans are well advanced, will provide opportunities for fundamental research which are now lacking. The Director of the Amani Research Station has been appointed to membership of the Advisory Board.

Research on coffee is proceeding at various centres in East Africa and it is highly desirable that the programmes should be co-ordinated. A valuable advance in this direction was made by the organization of a Coffee Planters Conference at Nairobi in July, 1932, to which representatives of Uganda and Tanganyika Territory were invited and so given the opportunity of hearing the work of the Kenya Department of Agriculture fully expounded. A representative conference of technical officers engaged in coffee investigations, on the lines of the Amani Soil Conference 1932, is now clearly required.

Sisal Investigations.

It is a matter of historical record that the sisal industry of East Africa has been built up with the progeny of some 85 bulbils which survived introduction from Florida in 1893. There is considerable likelihood that these came from one plant. They have been multiplied solely by vegetative offshoots, either suckers or bulbils. We have in consequence a most unusually uniform population, in which the only noticeable variation, apart from the effects of environmental factors, is in the presence or absence of marginal prickles on the leaves. Since this uniformity is reflected in the finished fibre, and since until recently, the preponderating utilization

of the fibre was for the not very exacting manufacture of binder twine, no intimate methods for the evaluation and comparison of quality have been required or developed.

The situation is now changing. The extension of the uses of sisal fibre affords opportunities for a more diversified product developed in different directions to serve particular purposes. To meet this demand we have the prospects of variation afforded by the sisal seedlings and seedling hybrids now beginning to reach maturity at Amani, and we have also the prospect of finding a diversity of qualities among other species of Agave, which appear never to have been systematically examined.

To compare and to select from the material thus made available requires the development of a special and largely original technique. The pursuit of this has occupied a good deal of the time and has taxed the ingenuity of the Plant Physiologist during the year. An efficient method of counting, measuring the cross section, classifying, and analysing the distribution of the fibres in the leaf has been achieved through the making of microtome sections, which can be recorded with any required degree of enlargement by direct projection on to bromide paper. Apparatus has been constructed capable of being worked by native assistants for the determination and recording of the tensile strength of individual fibres, their degree of elasticity, and their resistance to impact. An attempt is now being made to combine the first two of these measurements in a single machine.

An opportunity of applying these methods has been afforded by the arrival at maturity of a plot of *Agave amaniensis* planted at Sigi at the end of 1929. The suckers used were derived from a small group of plants existing under difficulties in the secondary growth of a remote part of the Sigi section of the Amani plantations. Attention had been drawn by the Superintendent of Plantations to their unusual length of leaf, in comparison with sisal. This and several other well-marked characters have been reproduced in the plants grown in the open, and the submission of specimens to Mr. Lyster H. Dewey, Fibre Expert to the United States Department of Agriculture, and to Professor William Trelease, of Illinois, the highest botanical authority on the genus, has led to the decision that the plant represents a well-marked and hitherto undescribed species. No clue has been found as to its origin. No specimen existed in the Herbarium, and if the plant is included in the list of introductions made from time to time to Amani it must have come in under the name of another species. Examples grown at four stations differing widely in altitude, soil, and rainfall, have in each case shown marked superiority in rate of growth to sisal.

Adequate samples of the first two cuttings were decorticated at Amboni by favour of the General Manager of Amboni Estates, Ltd. The percentage of fibre appears to be about the same as in sisal at the same stages, but the number of fibres per leaf is nearly double,

so that the fibre is much finer and softer. The tensile strength of individual fibres is decidedly greater than that of sisal when the measurements are adjusted to equal cross sectional areas.

There seems no reason to doubt that this species will either replace sisal to a considerable extent or supplement it and facilitate extension of present uses. It should, for example, be greatly superior to sisal for the proposed development of the local manufacture of coffee bags. Reports made by Messrs. Wigglesworth & Co., to whom samples were submitted by the Imperial Institute, are highly favourable. Further information as to the value of the fibre must await the accumulation of sufficient material for commercial tests.

Nothing is known of the poling propensities of the species, but it reproduces fairly freely by suckers after the second year. Calculations based on a reasonable rate of suckering show that the possible number of the offspring of a single plant reaches more than 50 millions in 15 years, so that its establishment on a commercial scale need not be unduly delayed.

Sisal Experiment Station.—Towards the end of the year under report, two meetings of the Committee of the Tanganyika Sisal Growers' Association were attended by representatives from the Department of Agriculture and of this Station, and had under discussion the proposed experiment station on the Tanga plain. It is understood that definite steps have been taken towards the acquisition of land and the provision of the necessary funds. The new station would provide facilities necessary for the development of the work in genetics and plant physiology included in the Amani programme.

Virus Disease Research.

Progress in this extremely difficult subject is only made by small steps, but any definite addition to knowledge has a far-reaching significance in view of the importance of virus diseases in both plant and animal pathology and the little that is known of their essential nature. The success recorded by the Plant Pathologist in delicate manipulations of the vector insect of the streak disease of maize has opened up a distinctly new line of investigation and results attained or in sight will attract the attention of all students of the subject. Dr. Storey has for his special field the virus diseases of tropical crop-plants. Knowledge of these has immediate agricultural importance with reference to their evasion or control and also forms an essential part of the world-wide line of attack on the problem of the nature of virus diseases in general. The recent recognition as virus diseases of the serious leaf-curl affections of cotton and tobacco affords examples of the need for specialist advice to be available.

The provision of additional insect-proof greenhouses at Amani, made possible by a grant from the Colonial Development Fund, will permit of a considerable widening of the range of intensive research.

Entomological Research.

The Entomologist has spent the greater part of his first year of work in the principal coffee area of Kenya Colony, engaged in the fundamental study of the climatic factors as they exist in and about the coffee trees and their relation to insect life. It is expected that intimate knowledge of this relation will, in some cases at least, enable adjustments to be made which will reduce the intensity of the prevalence of pests. The striking natural differences which exist in this respect between the various coffee-growing areas in East Africa, and which in many cases cannot be attributed to the accidents of distribution of the insect concerned, show that factors at present little understood may completely control the presence or absence in significant numbers of a given pest.

Soil Investigations.

The Soil Conference held at Amani in May, 1932, attended by representatives of Kenya, Uganda, Tanganyika Territory, and Zanzibar, was arranged with the object of securing the greatest possible degree of co-ordination in the efforts which are being made to lay the foundations of a systematic knowledge of the soils of the vast areas covered by the British Dependencies in East Africa. Agreements were reached on all essential matters brought forward for discussion. The function of the Amani Research Station as a convenient co-ordinating agency was recognized. The number of technical officers engaged is exceedingly small in relation to the amount of work which requires to be done and concerted action will avoid diffusion of energy which in these circumstances cannot be afforded.

The detailed examination and recording of soil characters is an unending and unexciting process, but examples have occurred during the year of its immediate usefulness. Essential information regarding soil acidities not otherwise available was supplied to Dr. H. H. Mann for the purposes of his report on the areas in Tanganyika Territory under consideration as to their suitability for the growing of tea. Similar data have provided what appears to be the key to the extreme variability of the root system of coffee as revealed by the investigations of the Plant Physiologist.

The disquieting symptoms of excessive alkalinity in the coffee soils of some parts of the Arusha district, due to the undiscriminating use for irrigation of the waters derived from Mount Meru, have led to the investigation of the streams concerned (in co-operation with the local officers of the Department of Agriculture) and consequent definition of their degree of suitability for the purpose.

Vegetable Insecticides.

Interesting results have been reached during the year in the investigation of local insecticide-yielding plants, especially *Tephrosia*

vogelii, which is so far the most promising. Though its product is notably inferior in certain respects to pyrethrum, the plant has the advantage of a very wide as compared with a narrowly restricted range, and the further advantage of cheap and easy cultivation and harvesting. Moreover, under many conditions it is the best or one of the best of plants for soil protection, either as a contour hedge or for general temporary shade, and its separate uses can be perfectly well combined. Work will be continued at Amani on the best methods of extraction and application of the insecticidal principle, and samples have been supplied for commercial assessment.

Systematic Botany.

The report of the Systematic Botanist contains a somewhat striking list of the many and diverse purposes served by the Herbarium, the function of which as a central service for East Africa is steadily increasing. Acknowledgement is again due to the Director of the Royal Botanic Gardens, Kew, for close co-operation and for extensive contributions of duplicate material. With regard to commercial products, actual and potential, the valuable services of the Imperial Institute have continued to be generously and promptly rendered on all occasions.

Ornithology.

As the list of actual and prospective publications shows, the research output of the Station continues to benefit very considerably from the assiduous pursuit—for the most part extra-official—of the study of African bird life by Mr. (and Mrs.) R. E. Moreau. The paper on the food of the red-billed oxpecker removes a good deal of doubt which existed regarding the services of this bird in the control of ticks and biting flies on wild and domestic mammals, which would appear to more than offset its propensity to cause injury by opening up incidental wounds. Mr. Moreau's close investigation of the factors influencing the distribution of birds, the subject of a projected series of papers of which No. 1 is ready for publication, will take an important place in the foundations of the developing science of animal ecology.

Kwamkoro Estate.

For the second year in succession Kwamkoro coffee shows a comfortable and useful margin of profit, due to the care with which expenditure is adjusted to prospective production. Apart from the use of the estate for experimental purposes no development is at present projected beyond the establishment, as circumstances permit, of areas of selected *robusta* to steady the violent fluctuations arising from the uncertain yield of the old *arabica* plantations. Later it should be possible gradually to plant up new fields of grafted *arabica* with good prospects of success.

Amani Plantations.

The plantation and nursery work of the Station and the service of plant distribution have been maintained at a high level of efficiency by the Superintendent of Plantations, who has also had charge of Kwamkoro coffee. Various new areas have been added to the land available for planting at Amani by the drainage of marsh, the clearing of useless tree plantations, and the reclamation of waste.

The plots of *Musa textilis*, which will form the only available source of planting material if the production of manila hemp ever becomes an East African industry, have been carefully tended and increased to the extent of the material available for propagation.

Library.

The Station Library is now an instrument of considerable efficiency, and deserves wider and more frequent use by the officers of the many Government departments to which, in one way or another, the extensive series of scientific periodicals should especially appeal.

W. NOWELL,
Director.

REPORT OF THE PLANT PATHOLOGIST.

I arrange my report under the headings used in that for the year 1931–32. I would repeat, however, that the main feature of the accepted programme of pathological research is the fundamental investigation of plant virus diseases. Upon these lines considerable progress has been made during the past year. The ultimate object of this work is a clearer understanding of the nature of the virus, and in consequence a more rational attack upon the problem of the control of these diseases of such immense importance to tropical agriculture.

(*a*) Virus Disease Investigations.

1. *The Function of the Vector-insect in the Transmission of Plant Viruses.*

One of the most striking features of the viruses that cause plant diseases is their dependence upon sucking insects for their natural dissemination. Usually the power to transmit a particular virus is shown by a single species of insect, or at most a few species. It is now generally held that the virus enters into some biological relation with the insect to which it is attuned, but of the nature of this relation little is definitely known. It is generally assumed that in feeding on a diseased plant the insect ingests the virus, which passes into the intestine and thence by some route to the salivary glands.

It is supposed that, if the insect then feeds on a healthy plant, the virus passes out with the saliva and causes the plant to become diseased. Since this process usually continues indefinitely even if the insect never feeds again on a diseased plant, it is further supposed that the virus multiplies somewhere in the body of the insect, so maintaining its concentration in the salivary glands.

The object of my recent studies has been to check these assumptions and to clarify some of the obscurities. The material of my work has been mainly *Cicadulina mbila* Naude, the vector of streak disease of maize. In my last report I placed on record that I had successfully bred active and inactive races of this species, able and unable respectively to transmit the virus. A full account of this work has since appeared (Proc. Roy. Soc., B, vol. 112, p. 46). The possession of these two races has provided an exceptional opportunity for comparative studies. The second feature upon which my recent work has depended has been the development of a technique for the mechanical inoculation of the virus into insects. The method consists of introducing the virus-bearing fluid into a puncture in the abdomen or leg with a finely pointed needle or glass micro-pipette, under the microscope. Owing to the small size of the insect, the injury caused is severe. Nevertheless a large proportion of the treated insects survive and may be tested by feeding upon healthy maize seedlings, so as to show the effect of the inoculation. Furthermore by the same technique it is possible to pick up on a needle fluids from different parts of one insect and transfer them to other insects.

By these methods I have been able to prove that, after feeding on a diseased maize plant, *C. mbila* will have the virus in the contents of its rectum. When, however, these contents are voided as faeces, the virus seems rapidly to disappear. A few hours after its first feed on a diseased plant, the active insect was found to have the virus in its blood. After a further few hours' delay the insect began to cause infections of plants upon which it fed. Thus it appeared that the insect had ingested the virus into its intestine, whence some of the virus had passed out into the blood. Presumably the virus was then carried by the blood to the salivary glands ; but my experimental studies of this feature of the problem are at present incomplete and I have no proof that the salivary glands perform this function.

These experiments traced, up to a point, the behaviour of the virus in the active insect after it had fed on a diseased plant. If the virus were introduced by puncture into the blood of an insect that had never fed on a diseased plant, the insect became viruliferous (able to cause infections). In this process the intestine had been short-circuited. But I found that such inoculated insects caused infections only irregularly, and after a short time ceased to cause any infections. From this and certain other evidence I

deduced that no multiplication of the virus occurred in inoculated insects.

The inactive races of *C. mbila* also proved to be susceptible to inoculation with the virus ; that is, if the virus was introduced by needle into their blood, they became viruliferous. Normally, however, in an inactive insect fed on a diseased plant, the virus was found in the rectum, but never in the blood. Thus its inability to transmit the virus is due to some property of the wall of the intestine, which opposes the passage of the virus outwards into the blood. If, however, a sterile needle was thrust into the abdomen in such a way that it was likely to penetrate some part of the intestine, the insects so treated now behaved as if they were active ; that is, if the puncture were made immediately before or immediately after the insect fed on a diseased plant, it would often become viruliferous. It is difficult to believe that an insect, in which part of the food flowed out into the blood through a hole in the intestine, could long survive; but many experiments confirmed this explanation of my results. It should be mentioned that throughout this work I encountered no single individual of an inactive race of *C. mbila* that could transmit, if uninjured : nevertheless by the simple process of puncture with a sterile needle I was able at will to render inactive insects viruliferous.

The same technique was employed for the transfer of blood to active *C. mbila* from variously treated active and inactive *C. mbila*, with a view to testing the possibility of conferring a passive immunity to the streak virus. There was, however, little prospect of success in this operation, and in fact all trials failed.

Other species of sucking insects were inoculated with the streak virus, and *C. mbila* with the viruses of maize stripe and mosaic diseases. The methods successful with inactive *C. mbila* failed in these experiments. Thus in their behaviour to a particular virus, insects fall into three classes : (*a*) those able to transmit, (*b*) those unable to transmit normally owing to a mechanism of resistance that may be overcome by suitable treatment, and (*c*) those apparently entirely unable to transmit under any circumstances.

A full account of the studies, of which the above is a brief summary, has been prepared for publication. They have opened up a considerable field for future work ; and, indeed, I have already made progress in several other lines of investigation, in which however my results are as yet incomplete.

2.—*The Breeding of Cicadulina Zeae China.*

Work with this species has given a clear indication that the power to transmit the streak virus is controlled by an hereditary factor. The insect has proved a difficult one to breed. Pure inactive races have been successfully established, but the active lines have hitherto all died out. Consequently I have been unable yet to study the genetics of this species.

3.—*Leaf-curl Disease of Tobacco.*

This disease is probably of growing importance in tobacco production in East African territories (as well as in Southern Rhodesia and South Africa). The proof that it is a virus disease, transmitted by a species of white fly, replacing the previously held incorrect hypotheses as to its causation, allows of more rational control measures than hitherto. The importance of the removal of over-wintering sources of the virus, which I stressed in my report to the Southern Rhodesia Department of Agriculture (*Rhodesia Agric. Journ.*, vol. 29, p. 186), has received ample confirmation in the observations of Mossop (*Rhodesia Agric. Journ.*, vol. 29, p. 869).

Should the disease increase in incidence greatly, as has happened with the similar disease of cotton in the Sudan, the only possible method of control might prove to be the use of immune varieties of tobacco. An attempt to breed immune strains has been begun. Seed of the standard varieties of tobacco in Nyasaland and Southern Rhodesia was supplied by the respective Departments of Agriculture. The first season's trials have been handicapped by the abnormal season, which caused the plants to flower before the disease had become epidemic. Nevertheless, preliminary selections have been possible. Several years must elapse before it can be decided whether this work will yield successful results.

Transmission experiments with tobacco leaf-curl have been continued, with a view to the understanding of the irregularity of symptom expression in infected plants, the behaviour of alternate host plants, and the possibility of differentiation of the disease into several types, as reported by Thung (*Meded. Proefst. Vorstenlandsche Tabak*, No. 72).

4.—*General.*

The new experimental greenhouses, the cost of which is met from a grant from the Colonial Development Fund, are nearing completion. They will permit of a considerable extension of my work. In particular they will facilitate the investigation of certain diseases of importance in Africa, known or suspected to be virus diseases. The mosaic of cassava, though known to be a virus disease, still remains without a definitely known vector. The "green-flower" disease of simsim, important in Uganda and Tanganyika, is suspected to be a virus disease, although no proof at present exists. The status of a mosaic-like disease of a particular variety of sugar cane still remains to be determined. The stripe disease of maize, transmitted by the leafhopper *Peregrinus maidis* Ashmead, requires further investigation. This is equally true of a streak-like disease of a particular variety of sugar cane, which appears not to behave like the well-known streak of Uba cane.

The investigation of all these problems requires large greenhouse space, but will occupy relatively little of a research worker's time.

Consequently I now hope to make progress with them, which has been impossible in the past.

(b) Ad Hoc Investigations.

Yellows Disease of Tea in Nyasaland.

A full account of my investigations of this disease, in collaboration with Mr. R. Leach, Mycologist in the Nyasaland Department of Agriculture, has been published (*Ann. Appl. Biol.*, vol. 20, p. 23). A short summary was published in the Nyasaland Department of Agriculture Bulletin No. 3 (N.S.).

(c) General.

During the greater part of the year under review my assistant, Mr. R. F. W. Nichols, was absent on leave. This fact has naturally lessened the year's output from the section; a more important effect, however, has been to prevent me from travelling any distance from the station, since the maintenance of my pure line cultures of insect vectors and of other experiments necessitates constant attention from a European officer. Consequently I have nothing to record under the heading of consultative visits.

H. H. Storey,
Plant Pathologist.

REPORT OF THE ENTOMOLOGIST.

As outlined in my report for the previous year, it was decided that the programme of the Entomologist should consist of an investigation into the ecology of *arabica* coffee plantations, with particular attention to the relation of climate to insect pests.

Almost the whole of the year under review has therefore been occupied with this work, for which purpose I have been stationed on a coffee plantation at Kiambu, Kenya, from May, 1932, until the end of March, 1933, with the exception of a short return to Amani during October and November, 1932, rendered advisable by the necessity for digesting the data so far accumulated.

The work which has been accomplished up to the present may conveniently be considered under three main heads.

Firstly, measurements have been made of the various climatic factors in a typical coffee plantation, and these have been compared with what may be termed the " standard " climate, as measured in a meteorological screen in the open. In this connexion three possibilities presented themselves :—

(1) that the standard climate would be so nearly identical with that in a coffee bush that for all practical purposes a knowledge of the former would suffice. This was no doubt

unlikely, and it can be definitely said that it is not the case. Actually, to mention one factor only, temperature, the conditions in a coffee bush vary from the standard as much as the standard varies over some five or six thousand feet of altitude.

(2) that the climate of a coffee bush would be found not only to be widely different from the standard climate but to have no correlation with it, so that a knowledge of the standard climate would be entirely useless for ecological purposes. However, as pointed out by Uvarov (*Insects and Climate*, p. 170, 1931), the eco-climate in a growing crop is not unrelated to the standard climate in a meteorological screen, since both depend on the same meteorological events. It is, in fact, already reasonably certain that the truth lies in

(3) that although the climate of a coffee plantation differs greatly from the standard, yet from a knowledge of the latter it should be possible to deduce the former within a fair degree of accuracy.

That is to say, that if the standard meteorological data of a district are known, it is expected that it will be possible to say what the conditions are in a coffee plantation in that neighbourhood, or if one is considering an area as yet undeveloped, to predict what they would be should coffee be planted.

The more important meteorological data which have been collected are air temperatures and humidities, both inside and between the bushes, and at different heights above the ground ; soil temperatures on the surface, and at 1, 5, and 15 centimetres ; relative wind-velocities and relative rates of evaporation.

It may be added that all observations are made by the Entomologist himself, and that the recording thermographs and hygrographs in use have been checked several times daily by an Assmann psychrometer.

Secondly, an attempt has been made to evaluate the influence of various factors which modify the climate of a coffee plantation. Such are the presence of shade trees and wind-breaks, closeness of spacing, style of pruning, mulches and cover crops, and the slope of the land. It is obvious that, with the exception of the last, all these are susceptible to control, and it can be said that if as is hoped, it should prove possible to define the optimum climate either for the coffee plant itself, or for the control of a pest or disease, the production of that climate will lie to a considerable extent in the hands of the planter.

The third line of approach to the problem, namely, the influence of the several climatic factors, and combinations of them, on various insect pests, is as doubtless the most important as it is certainly the most difficult.

Numerous quantitative collections of the population of coffee bushes in different situations, the eco-climates of which have been studied, have been made ; the results have not yet been correlated, and it would be premature to comment on them.

A single instance may, however, be tentatively given to indicate the nature of the problems that arise. It was observed that the larvae of the coffee leaf-miner (*Leucoptera coffeella*, Guér.) are capable of standing distinctly high temperatures. One of 44·5° was recorded in a mine occupied by a living larva of this species, and it is almost certain that higher temperatures than this frequently occur without proving fatal. It is therefore perhaps justifiable to assume, in the absence, as yet, of direct experiment, that the optimum temperature for these larvae, i.e., that at which the greatest number complete their development in the shortest time, is also high. Consequently, at first sight it would be thought that a comparatively warm eco-climate would be most favourable to outbreaks of this pest. This is not, however, entirely borne out by the facts. It is true that infestations frequently start in the warmer localities most exposed to direct solar radiation, but in general they appear to persist longest where the eco-climate is comparatively cool, and the leaves of the coffee-bush are less fully exposed to direct sunlight.

This apparent anomaly has, it is thought, been explained by comparative counts of the percentage of parasitism of larvae living in different eco-climates. It has been found, at any rate after an outbreak has been in force for some little time, that the percentage of larvae parasitised is considerably higher among those in leaves exposed to the sun than it is among those living in shaded leaves.

The explanation therefore appears to be that, while the optimum temperature for *Leucoptera* larvae is probably comparatively high, that for its parasites is higher still.

I wish to record my appreciation of the kindness of Mr. P. J. H. Coldham and Mr. G. Bentley of Kiambu in allowing me the use of their coffee plantations for experiments and observations, and of the valuable assistance given by Mr. A. Walter, Director of the East African Meteorological Service, in the loan of instruments.

T. W. Kirkpatrick,
Entomologist.

REPORT OF THE SOIL CHEMIST.

1. *General Survey and Classification.*
2. *Special Studies of the Soil Groups.*

Questions involved in soil survey were discussed, and I think advanced considerably, at a Conference of East African Soil Chemists held at Amani from 21st to 26th May, 1932. The proceedings of

this Conference have been published.* Under the heads " Proposed Soil Map of East Africa " and " Terminology in naming and classifying soils " the findings were, shortly, as follows :—

A scale of 1 : 2,000,000 will best serve to express the kind of information on soils that is likely to become available within the next two or three years with present resources, which allow of no systematic area survey.

Insets or supplements on a larger scale can be used for particular areas for which more detailed knowledge comes to hand, e.g., for Zanzibar, parts of Nyasaland, or important plantation districts.

A notation discontinuous with the rest will be desirable for large parts of East Africa for which direct information on soils is hard to come by (owing to their remoteness or barrenness), in order to distinguish them clearly from the parts where mapping is based on direct soil evidence.

The categories of classification for the purpose of this map must be fairly comprehensive. A provisional list of eight such categories, labelled not according to the soil-forming factors presumed to be operative but according to soil-profile characters as found, has been agreed upon. The smaller units " type," " series," and " suite " will be useful locally as analytical tools for the sorting of observations, but will not appear on the general East African map, at least in its first draft.

It is hoped to prepare the first draft of the 1 : 2,000,000 map in time to present it at the International Congress of Soil Science to be held in England in July, 1935. A further meeting of East African soil chemists before that date will be desirable, probably late in 1934. In the meantime samples and descriptions of the principal soil units of the several territories are to be furnished to Amani to enable them to be correlated as the classification and mapping proceeds.

Since the date of the Conference there has been further correspondence, initiated from Amani, on the meaning to be attached to the smaller-unit terms at present in use. It has been found desirable to relax the rigour of definition of the *series*, and to distinguish two separate kinds of grouping of related soils which are at present merged in the *suite*, possibly abandoning the latter word entirely. These developments in nomenclature, which reflect developments in our understanding of the fundamental relationships between different but allied soils, are being discussed simultaneously with leading workers in Europe and America in order to avoid, if possible, the establishment of too local a system in East Africa.

The Agricultural Chemist in Uganda has furnished Amani with a number of soil profiles occurring in a defined relationship to each

* Technical Conferences of the East African Dependencies : *Proceedings of a Conference of East African Soil Chemists held at the Agricultural Research Station, Amani, Tanganyika Territory,* 1932 (Government Printer, Nairobi).

other as regards topography and drainage. They represent soil conditions over a large part of the Buganda Province. Chemical work on them is now in progress on an agreed programme in both laboratories.

There is still no Agricultural Chemist in Tanganyika, but the keenness of the field officers of the Department of Agriculture has again this year resulted in my receiving much well-collected material representing soils of this Territory, notably from the volcanic country surrounding Rungwe Mountain at the head of Lake Nyasa, from the neighbourhood of Mwanza and of Bukoba, and from West Usambara, Kilimanjaro, and Meru in localities not before represented.

Kenya, Zanzibar, Nyasaland, and Northern Rhodesia have still not reached the stage of sending material representing their principal soils to Amani, under the scheme defining Amani's central functions in this matter which was arranged in 1930 and confirmed at the Conference of last May.

My own travelling during the year has consisted only in a few days spent in the Moshi area. It has, however, enabled me to classify provisionally some of the pedocalic soils of the low-rainfall country lying at the foot of Kilimanjaro (namely, those around Engare Nairobi, Arusha Chini, and Taveta).

Laboratory work to be reported in this section has included a large number of determinations of organic carbon and of nitrogen, which are making it clear what organic matter content may be expected in virgin and cultivated soils over a considerable range of conditions. About one hundred complete profiles have been examined as to acidity, as measured by the hydrogen electrode. A typescript report summarising these measurements for all localities in the Tanga, Northern, Iringa, and Bukoba Provinces of Tanganyika was circulated in February. An earlier note of some of the results on soil acidity was placed at the disposal of Dr. Mann to assist his consideration of the possibilities of tea-growing in the Territory.

The Geological Survey Department of Tanganyika have rendered generous assistance in several ways. A representative of the Department (Dr. D. R. Grantham) attended the Soil Chemists' Conference in May. Copies of geological maps of certain areas in south Tanganyika, embodying the surveyor's rough classification of the soils, have been furnished ; and some fifty rock-specimens representing the parent-materials of soils have been identified for me and described petrographically.

I also record gratefully an offer of assistance in the laboratory work of soil survey that has been made by the Director of the Imperial Institute. Three schemes of work were proposed from Amani in accepting this offer. These concerned mineralogical work on soil fractions (more especially clay fractions), ultimate analyses of clay fractions, and an attempt at a regional survey of the potash

and phosphate status of soils, respectively. The second of these schemes has been approved, and the third provisionally so, pending experience of the amount of analytical work it is likely to involve. The first batch of material under the second scheme (viz., the clay fractions of 26 Usambara rain-forest soils) was despatched to London in February this year.

The concluding paragraph of the section on soil survey in last year's report referred to the desirability of setting up for permanent display an exhibit of representative soil profiles. Fifty profiles are now so set up. This nucleus of a museum of East African soils has already aroused much interest amongst both technical and lay visitors, besides being an aid to my own work ; and I attach importance to its further development. Its better housing and display (at present it has little more than storage) will, I hope, be provided for in the coming year.

3.—*Manuring.*

The lay-out of a field experiment on the manuring of *arabica* coffee at Kwamkoro was described in last year's report. The weighings of the first year's crop are now to hand, and from an appropriately cautious interpretation of these preliminary figures it seems likely that there has been a small positive effect of fertilisers on yield of cherry ; but there is no guidance yet on the merits of the different fertiliser combinations. Harvest extended from 26th July to 16th December, and during this period the produce of the 48 plots was picked and weighed separately 29 times. The supervision required was however less than this might indicate or than had been anticipated, for the weighing and recording was successfully entrusted to an African (Swahili-speaking) laboratory hand, after a little instruction.

During the year the Physiologist's observations on the extent of spread of the root-systems of old coffee trees in this soil-type have made it clear that experimental plots should be bordered by a double row of guard-trees. This and the large observed plot-to-plot variation and probably large tree-to-tree variation in yield have made it desirable to modify the experiment in order to extract the significances more precisely. For the next and succeeding harvests it is proposed to eliminate all edge-trees from the weighings, whilst continuing to treat them as hitherto ; and from the residual "kernel" of each plot to select x trees at random for individual (tree by tree) record of yield, where x is the minimum number considered to form a sufficient sample of the tree population. From notes made by the Geneticist during his work on selection of coffee varieties by yield, it appears that x on the Kwamkoro plantations is about 10. Some of the plots have such an irregular stand of trees that it may not be possible to obtain the minimum number x in the "kernel" after eliminating guard-trees, and these plots may have to be dropped from the experiment. The experiment as a whole

may indeed require reconsideration, as this stand of old trees is certainly far from ideal material from which to expect representative or statistically valid results.

A block of 10 measured plots contiguous to but not randomised with the fertiliser plots were mulched three times during the year with cut bracken strewn densely six inches deep over the whole soil surface. The weighed yields from these plots cannot of course be brought into quantitative comparison with those of the fertilised or control plots, but the yields as recorded, and the Superintendent's qualitative opinion on the way the mulched trees have borne their crop and retained leafage, have made it seem worth while to try whether mulching with bracken will improve the response to a dressing of a complete artificial fertiliser. The bracken plots will therefore be changed to the "single-tree weighing, guard-trees eliminated" procedure this year, and next season they will be divided at random into five blocks of two plots each, one plot in each block to be mulched, the other to be mulched and fertilised.

(*The above section has been written jointly with the Geneticist.*)

The surface soil of the above experimental plots is very acid (pH = 4·9 in water-suspension, 4·1 in KCl-suspension) and approximately the same degree of acidity persists into the subsoil throughout the profile. In these respects the soil is quite typical of the East Usambara upland. On such a soil it may naturally be asked whether acidity is limiting the yield of coffee and also its response to manuring. During the year an approach towards answering this question has been made by multiplying the survey data on soil acidity in all the coffee districts, but the answer is likely to be complex, and an attack by field experiment has not yet been found practicable. If, as seems possible, the acid-soil districts could more profitably take to tea instead of persisting with coffee, the question would lose practical interest.

4. *Nitrogen-changes.*

The simple nitrification experiment described under this head in last year's report gave a very clear-cut, though hardly a novel, result. During the 10 weeks of the experiment the nitrate-content of moistened but otherwise untreated soil (the soil of the plots discussed in the previous section) rose slightly, from 28 to 40 parts per million. Addition of organic matter of low nitrogen-content (1·5 per cent. N, powdered forest-floor leafage), to a parallel series, reduced the original nitrate-content to *nil* in the first fortnight, at which level it stayed to the end of the experiment. Addition of organic matter of high nitrogen-content (4·5 per cent. N, powdered *Crotalaria* leafage) initially reduced the soil's nitrate-content to half its value but raised the ammonia-content from 5 to 110 parts per million. Thereafter the nitrate increased steadily to 110 parts, while ammonia dropped correspondingly to 15 parts.

Such results must of course be interpreted cautiously, and should be elaborated considerably before they can give useful guidance on field practice. But this type of experiment is obviously capable of being adapted to reflect the conditions of any green-manuring routine fairly closely, and should be profitable to pursue in view of the present keen interest of coffee-growers in green-manuring. The experiment described, however, (simplest of its type though it was), occupied two full days per week of the Chemist's time for 10 weeks.* I do not consider it practicable with one assistant only to embark seriously on a programme of such work at present.

5. *Erosion.*

I have no progress to report. I have not been able to visit the parts of East Africa where soil erosion is the great outstanding problem, and, had I done so, the working-up of my material would have required the attention of one full-time assistant. The Soil Erosion Committee has not advised making provision for soil survey or soil investigations in the affected areas.

6. *Irrigation Problems.*

The preliminary analyses of water-samples from the streams used for irrigation on the slopes of Mount Meru, Tanganyika, were continued, and, in view of the interest of the results to the soil survey, the work was extended to include all the streams rising on Meru whether used for irrigation or not. The composition of the waters has been shown to bear a close relation to the topography, geology, and climate of the mountain-slopes, and reflects the current processes of soil formation. The results have the practical value that they afford guidance on the expectation of cumulative ill effects through using poor-quality water in any given scheme of irrigation, poor quality in this district meaning a high relative proportion of alkali carbonates ("soda") in the total dissolved salts. Briefly, the waters are of best quality (though still not very good) on the wettest, south slopes of the mountain, where the soils are well-developed brown or grey-brown loams, but are soda-bearing on the south-west, west, north, east, and south-east, where the soils are a powdery and relatively raw volcanic ash. The results have been fully discussed in a paper ("A Chemical Survey of the Waters of Mount Meru" jointly by D. Sturdy, W. E. Calton, and myself) now in course of publication in the Journal of the East Africa and Uganda Natural History Society.

Miscellaneous.

At the Soil Chemists' Conference of last May a measure of standardization of analytical methods for East Africa was agreed upon.

* If sulphur-changes as well as nitrogen-changes had been followed analytically in this experiment, as discussed under head 8 of this report last year, the two days would have become three.

In the particular matter of the measurement of soil acidity, it was agreed to use the hydrogen-electrode method exclusively for the present, and I have been able to employ the supply of direct current now available at the Station to provide electrolytic hydrogen continuously as required, for this purpose, in place of the inconvenient and expensive cylinders formerly imported.

The Conference also discussed the problems involved in the primitive practice of shifting cultivation in its very various forms, and framed a statement of some of the lines of possible experimental attack upon them. Although information bearing on these problems is being secured indirectly in the course of other work, e.g., the survey work on organic matter and soil acidity, no formal programme of research on shifting cultivation is at present being undertaken.

My assistant, Mr. W. E. Calton, has been on leave in England during the last six months of the year. The disparity between the staffing of soil work at Amani and the programme which the soil section could usefully undertake has therefore in the present year, as in the two previous years of this series of reports, been accentuated.

G. Milne,
Soil Chemist.

REPORT OF THE BIOCHEMIST.

Insecticides from Local Plants.

A paper will shortly be published setting out in detail the results of my investigations on this subject. The gist of the results so far obtained is as follows :—

(*a*) No new insecticidal principle has been discovered that can compare in killing value with the standard poisons such as nicotine and pyrethrum.

(*b*) Two local plants (*Cassia* and *Barringtonia* spp.) which have been examined have insecticidal properties which, although not comparable with nicotine, might nevertheless be useful as insecticides against such pests as thrips and aphis, on plantations where these plants grow wild.

(*c*) Considerable work has been done on *Tephrosia* spp., especially *T. vogelii*, which is widespread in East Africa. Extracts from *T. vogelii* are, weight for weight, more toxic than nicotine to thrips and aphis, but somewhat less so than pyrethrum ; it is, however, far easier to cultivate.

(*d*) No insecticide to compare in quick killing power with pyrethrum has been discovered which could take its place in paraffin sprays against Antestia and Lygus. Work however is being done on the use of Tephrosia extracts for household

sprays against flies, mosquitoes, and similar insects, and it is hoped that the cheaper Tephrosia extracts can replace the dearer pyrethrum ones in many cases.

The great advantage of the plants so far examined is that planters should, with little trouble, be able to make their own insecticides at a much lower cost than that of nicotine. The really efficient plants such as the Tephrosia species have a definite use as cover crops and contour hedges.

Fermentation of Coffee.

In continuation of the preliminary trials reported last year on the cleaning of coffee by weak acid instead of by fermentation, a large-scale trial was carried out. During the coffee season at Kwamkoro a whole day's picking, amounting to about 16 cwt., was treated with acid.

A large wooden box, made of *mvule*, with a screw-down lid and provided with rockers was used and the pulped coffee was shaken in it with 1 per cent. sulphuric acid for 20 minutes. The acid was then run off and the coffee washed and dried in the usual way. Four cwt. of finished parchment was obtained and this was shipped home for sale at the same time as the bulk of the fermented coffee, but given a different mark for identification purposes (SS Kwamkoro).

The result was somewhat disappointing. The brokers reported as follows :—

> " The mark Kwamkoro is good size palish green, slightly mixed with pale berries. The roast is fairly good, but mixed with an occasional pale, the liquor being about fair in strength and flavour. Worth about Shs.75 to Shs.76 per cwt.
>
> The mark SS Kwamkoro is fair size palish green, but not quite so fresh in appearance as the above. The roast is fairly good, but mixed with an occasional pale, the liquor being about fair in strength and flavour. Worth about Shs.68 per cwt."

It will be seen that so far as liquoring is concerned the two coffees are reported identical, nevertheless, they are valued at Shs.7 to Shs.8 difference on account of appearance. Actually they fetched Shs.86/6 and Shs.63/6, respectively, a difference of £23 a ton based on appearance only. No doubt the smallness in bulk of the acid-cleaned sample reduced its auction value.

Reports, seen by courtesy of the Tanganyika Agricultural Department, on coffee cleaned mechanically in the Raoeng pulper instead of by fermentation confirm our views here that the process of fermentation, as such, has no beneficial effect on quality, but that the process of drying is an important factor in preparation.

Experiments suggested by this conclusion will be carried out to ascertain the effects of temperature and length of drying, singly and in conjunction, on the finished product.

Carbohydrate-Nitrogen Ratio in Coffee.

As a quick means of settling the problem of overbearing and die-back, the C/N ratio has proved a complete failure. Different series of results have pointed in opposite directions and frequently have not differed from results for healthy trees. This portion of the work has therefore been abandoned.

A possible reason for these irregularities is that all the coffee trees around Amani have at some not remote date suffered more or less from die-back and have never really recovered from it, so that we are merely comparing unhealthy trees with very unhealthy ones.

As regards the general collection of data on C/N ratio the experimental trees on Lion Hill suffered so severely from die-back as to be useless for a time for this work. They are now, after heavy manuring and pruning, in quite good condition and ready for work to be resumed.

It remains to be seen, however, if there really is any scientific value in the C/N ratio ; personally, I am doubtful of it.

Coffee Ash Analyses.

A number of ash analyses of various parts of the coffee plant have been carried out in an endeavour to differentiate between healthy and die-back trees. Results so far have been conflicting but do not point to a deficiency in any one element.

Here again lack of really healthy material as a standard may account for the conflicting results. This difficulty can, however, probably be remedied, since mineral content will not change, as will carbohydrate content, if the material is collected elsewhere and takes some time to reach the laboratory. Mr. Kirkpatrick has kindly collected samples for me from some of the best coffee trees in Kenya and it is intended to use these as standards against which to compare the local die-back trees.

A large number of estimations of copper were made in view of the facts that copper sprays are beneficial in preventing leaf fall in coffee, and that copper has been found deficient for some crops in other parts of the world. Far from being deficient, copper was found to be plentiful compared with figures for other plants.

Essential Oils.

In and around Amani there are several indigenous essential oil bearing plants and incidentally I have devoted some time to their examination with a view to suggesting new crops for parts of East Africa. Methods of valuation have again not been very satisfactory, one new oil being described and valued quite differently by two different firms in England. Work is continuing on these oils.

As regards introduced essential oil plants I have examined several and have found the yield and quality, on a small scale, from lemon grass (*Cymbopogon citratus*) to be so good that an acre has been planted out to determine the value of oil produced in a year.

Kweme Nuts.

Resulting from the interest of a local planter, some attention is being given to the kweme nut, the seed of *Telfairia pedata*. These nuts yield about 60 per cent. of an oil which has been described as suitable to some extent for replacing olive oil ; the husks, however, contain a very bitter principle which is partly absorbed by the oil on crushing the seeds, rendering the oil unfit for food. The flat shape of the seeds makes the removal of the husk without crushing the kernel very difficult and uneconomical.

I have found several solvents for removing this bitter principle but the problem is, of course, to find a very cheap method if the oil is to compete with other vegetable oils. If this can be done the kweme should prove a useful crop.

A number of miscellaneous analyses have been made during the year, including sugar estimation, examination of sisal waste and salt water washings, insecticidal substances, etc. Pending the appointment of an agricultural chemist, some of these have been made for the Tanganyika Department of Agriculture and a few, where matters of interest were concerned, for other people, official and unofficial. The number has to be strictly limited to avoid dislocation of the regular research work.

R. R. Worsley,
Biochemist.

REPORT OF THE PLANT PHYSIOLOGIST.

Coffee Investigations.

1. *Root Studies.*

So far as coffee is concerned the greater part of the year under review has been spent in further field work on the root system of *Coffea arabica*. Thirteen areas have been studied ; on Kilimanjaro, on Meru, on Mondul, in the East Usambaras, and near Nairobi in Kenya. A total of 67 trees has been excavated.

The root systems as found in the areas studied can be considered as arising from one type, which is capable of modification by soil conditions. This modification is so profound that at present it is very difficult to generalize on root systems, at any rate from the practical view-point. Cultural methods suitable for each area will probably differ as widely as do their root forms. The typical system referred to is characterized among other things, by deep rooting and by even distribution of feeding roots throughout the soil.

The effects of certain soil conditions, among which may be mentioned hardpan, gravel strata, high water-table, and aeration, have been studied. Data on soil reaction provided by the Soil Chemist at Amani have enabled the effect of soil acidity to be studied. A remarkable correlation exists between root distribution and the acidity profile of the soil, and on field evidence the acid limit of optimum acidity is about pH5·8. In other words a neutral or nearly neutral soil favours the growth of coffee roots. The figure given is, of course, only approximate, since other factors can alter the effect of acidity on the roots.

The failure of coffee in the East Usambaras and its doubtful success on parts of Kilimanjaro are ascribed to high soil acidity.

I have also been able to show that the die-back of coffee which follows heavy cropping is associated with a depletion of the storage carbohydrates to the vanishing point, and is accompanied by extensive damage to the roots. This damage appears to be permanent and to increase in importance with the age of the tree at the time of die-back. Further work on this subject is proposed for the 1933 cropping season, when it is hoped to investigate the time-relations of starch depletion, root die-back, and branch die-back ; the effects of certain treatments will also receive attention.

A paper giving a full account of the root investigations has been prepared for publication.

2.—*Shade Experiment.*

The defoliation and die-back noted in my last report were so severe that it was at first extremely doubtful whether the trees would recover. They have now been removed from their containers and given free range. Liberal applications of farmyard manure and of complete artificials have been made, while a heavy grass mulch is being maintained. Owing to the soil reaction the roots are confined to the surface layer, and as the site is on a hill-top this has been subjected to considerable leaching. In spite of the poor root development the response to treatment has been remarkable, and it is hoped that it will be found possible to resume the taking of records shortly.

During the year the fabric used for shade has been replaced by slats, the average light intensity in each series being adjusted to its previous value. Under East Usambara conditions a reduction of light intensity of 15–20 per cent. has given by far the best results.

3.—*C/N Ratios.*

The present position of this work is reported on by the Biochemist.

4.—*Other Experimental Work.*

Preliminary trials have been made with coffee grown in sand culture in various solutions. This work has been rendered possible by

the discovery of a local source of sand of satisfactory purity. Seedling coffee has also been planted in glass-sided observation boxes for observations of root growth. It is unfortunate that the care of such experiments has had to be left to natives while I have been on safari.

Sisal Investigations.

No experimental work on the sisal plant has been carried out during the past year. It is impossible to carry out field experiments at Amani for a number of reasons, and experience has shown that any attempt to do experimental as distinct from observational work on private estates is foredoomed to failure.

It is becoming increasingly apparent that little scientific knowledge exists of sisal or similar fibres. It is at present impossible to assess the desirability or otherwise of any fibre sample short of sending a large trial shipment to commercial users. Even then it is not certain what qualities either of the fibre or the product are regarded as desirable. The position is even worse than that in the early days of the application of botanical science to the cotton industry. Experienced cotton testers were then available to give a judgment on small samples, and not infrequently such judgments were upheld by later and more scientific methods. I am not aware of any person who claims to be able to estimate the range of usefulness of a fibre sample by inspection.

A definite need exists for criteria which can be applied to new fibre plants, to sisal seedlings or selections, and to the fibre produced by such plants. Such criteria should be sufficiently exact to enable comparisons to be made between comparatively small samples of fibre, and should also be applicable to single plants. As genetical work progresses, and as new fibre-producing plants are introduced, some method of evaluating fibre characters will have to be used, as it is obviously impracticable to propagate each plant sufficiently to provide a shipment of commercial size. Apart from the loss of time involved, the expense and the acreage involved would be tremendous.

In view of the foregoing, search for such criteria has been made during the past year. The ultimate value of the data provided by such methods will depend on whether they will enable judgments of comparative value to be obtained locally, or whether they will ultimately be capable of correlation with qualities which may be desired by the buyer and user of fibres ; hence the use that has been made of physical as distinct from chemical qualities.

The following have been chosen as being worthy of attention :—

Fibre Qualities.

(*a*) Strength.
(*b*) Elasticity.
(*c*) Fineness.
(*d*) Fibre type.

Leaf Characteristics.

(*e*) Total number of fibres per leaf.
(*f*) Type of fibre in the leaf.

Machines have been devised and made at Amani which enable sufficiently accurate estimates of strength to be made on samples of about 400 fibres, i.e., the fibre from a single leaf will suffice for a complete series of tests. Strength is measured by an impact tester, which measures the amount of work done on a fibre when broken by a sudden blow. It is also measured by means of a machine which applies a uniformly increasing strain to a fibre, recording that at which breaking takes place. Elasticity is measured by recording extensions under a uniformly increasing strain. Owing to the great variation in sisal fibre a considerable number of determinations is necessary, but as the machines can be worked by trained natives this is of little moment. It is at present doubtful whether the elasticity of such a fibre as sisal can be measured directly, owing to the considerable diameter variation.

Fineness of fibre is readily measurable by obtaining the diameters of fibres suitably magnified by means of a micro-projector. Preparations can be made by natives, and the actual measurement takes but a little time. From measurements of breaking strain and diameter the tensile strength of the fibre can be calculated. The type of fibre can be estimated by a microscopical study in cross section. Fibres of various types occur in *Agave* leaves. Some of these fragment to a greater or less degree during manufacturing processes; hence, according to the severity of decortication and brushing, the type of fibre appears to vary.

The fibre characteristics of the plant are obtained by the study of cross sections of leaves. These can be made by the use of a suitable microtome, and are enlarged direct at a magnification of about three diameters. Rough classification into fibre types can be made by inspection of such prints, and counts of total fibre number can be made by native assistants. The number of fibres per leaf is thought to be a factor of some importance.

The methods outlined above have been applied to *Agave sisalana* and also to a new fibre-producing agave provisionally named *Agave amaniensis*. The results have been sufficiently striking to demonstrate the value of the methods, and also to show in no uncertain manner the marked superiority of the new fibre in many respects.

During the year the classification of the physiological literature in the Library has been brought up to date.

F. J. Nutman,
Plant Physiologist.

REPORT OF THE PLANT GENETICIST.

I was absent on leave from June, 1932, to January, 1933. During this period the only work done in this section was the routine recording of yields and bean data from the coffee plots.

A number of hybridizations of coffee and of agave species had not matured at the time of my departure ; these were harvested and sown.

Coffee.

The data accumulating from studies on selected coffee material have not yet reached proportions which permit of a critical survey of the immediate value of plant selection. Most of the trees under observation have only begun to come into bearing during the 1932 season. In the offspring of single trees grown from seed produced by uncontrolled pollination, the variation in both vegetative and reproductive characters is considerable in many lines, while others appear to be fairly uniform.

A second generation from selected plants, raised from seed produced both from controlled and open pollination, is now being grown.

All the coffee hybrids so far made have been interspecific crosses between selected plants of *C. arabica* and *C. robusta*. Where *C. arabica* has been used as the female parent a fair number of seeds have been collected. The bulk of the seed has been poorly filled and the texture rather spongy, but germination was found to be fairly good. In the majority of the reciprocal crosses a similar development of the seed was obtained, but germination was a complete failure.

The seedlings of the first-mentioned crosses, with the exception of one family, resemble the *arabica* parent in general appearance. The exceptional family is very like *robusta*.

One or two of the F1 plants have commenced flowering at the age of eighteen months while still in the nursery.

The work on vegetative propagation was in abeyance during my absence. A certain amount of grafting was carried out by the nursery staff, for notes of which see the Report of the Superintendent of Plantations.

The investigations on the factors influencing the liquoring quality of coffee are proceeding. The results of the tests on the first batch of samples were unsatisfactory owing to the method of presentation of the report on the characters of the samples not proving suitable for close analysis. A meeting with the firms responsible for the carrying out of the tests was arranged by the Imperial Institute and a scheme of evaluation according to a scale of points was drawn up.

Sisal.

An analysis of data supplied by a number of sisal estates in Kenya and Tanganyika, on the variability of fibre content of the plant, has been completed. The variation shown is small. The indications are that the production per acre depends more on spacing and the number of leaves produced by the plants than on the variation in fibre content of the leaf. The question of variation in leaf number requires investigation and is receiving attention.

The seedling plants of *A. sisalana* have been kept under observation. The spiny character of the leaf margins has been retained, none showing any tendency towards the smooth leaf edge of the parent. An examination of cross sections of the leaves of a few of the more vigorously growing specimens has shown that fibre content and number of fibres are not widely different from *sisalana* ; the examinations are being continued.

Further supplies of seed have been obtained through the courtesy of J. McCrae, Esq., Longonot, Kenya. Up to date no success has been obtained in inducing seed production in Amani by mutilation of the young poles.

The hybrid plants of *A. angustifolia* by *A. sisalana* are showing a great range in variation. About 230 plants of this cross have been planted out in the field. In addition we have available for study a good number of plants of the cross *A. angustifolia* by *A. ingens* and the reciprocal. In both of the latter crosses the young plants show a marked resemblance to the *ingens* parent.

It has been observed that *A. fourcroydes* sets seed on the normal inflorescence on the coast and it is hoped to make use of this fact as soon as newly-poling plants are available.

Seedlings raised from self-pollination of *A. angustifolia* are beginning to show considerable variation from the parental type, which reflects some doubt as to the true specific nature of this plant.

Large plots of sisal raised from bulbils have been planted out, taken from single plants to afford material for a survey of the variability of the plant and to afford information as a guide in the laying out of experimental plots.

Agave amaniensis.

The development of a new species of Agave found in the plantations at Amani is affording great interest. Two-year-old plots are in existence in the coastal area and at the foot of the Usambaras near Korogwe. Growing alongside estate sisal suckers they show a more vigorous habit of growth. The fibre from this plant has been the subject of favourable reports from home and is much finer than ordinary sisal.

The oldest block of plants on the station has yielded an average of about 65 leaves per plant up to the age of three years and three months. The percentage of fibre is about the same as sisal but the leaves on the average are considerably heavier.

L. R. Doughty,
Plant Geneticist.

REPORT OF THE SYSTEMATIC BOTANIST.

Herbarium.

During the year the work of this section in a consultative capacity has steadily increased and a considerable amount of botanical material has been received for identification.

A total of 1,867 specimens were identified and information supplied under the following heads :—

Botanical surveys in Tanganyika Territory, Zanzibar, and Pemba.

Green manure and cover-crop plants.

Host plants of insect pests and insect-transmitted virus diseases.

Ecology of pasture and grazing areas.

Browse and fodder plants, including grasses.

Plants suspected of being harmful to stock.

Shade trees.

Indigenous forest trees.

Weeds of sisal plantations.

Food plants of locusts.

Plants in relation to bird ecology.

Fish-poison plants of possible interest as insecticides.

Other economic plants, indigenous and exotic.

Unidentified specimens in the German collections.

Information in these connexions was supplied among others, to the following correspondents :—

Department of Agriculture, Tanganyika Territory.

Department of Veterinary Science and Animal Husbandry, Tanganyika Territory.

Forestry Department, Tanganyika Territory.

Zanzibar Museum, Zanzibar.

Amani Staff.

Various individuals engaged in local agricultural industries.

The native banana varieties referred to in the Fourth Annual Report,* p. 35, are commencing to fruit and records and photographs are being taken from time to time as the bunches ripen.

Up to date six varieties have been dealt with and these seem to be fairly constant in regard to differences in sizes of bunches and shapes of fruits. Unfortunately this does not apply to the native names under which the collection has been brought together. A variety has fruited over which native opinion in the same village community differs to the extent of four Kiswahili and Kishambala varietal names.

The information collected whilst engaged on the botanical survey of the economic plants in the Amani Plantations is being verified and written up as other duties permit, and a report on the survey prepared for the Director.

Information is being steadily collected with regard to the native names of plants and the part the plants play in native economy. Information on the latter subject is very difficult to obtain, owing either to a general lack of knowledge amongst the natives themselves, or to their diffidence in imparting information to a European where their customs and usage are concerned.

Type Species.

Whilst determining specimens for various departments and individuals, 27 type specimens of various species were found in the Herbarium and recorded. The following new species from the Herbarium have been described :—

Erythrina rotundato obovata E. G. Baker in Kew Bull. 1932, p. 95 (Papilionaceae) T.T. ; S.W. Umba Steppe, Kivingo, altitude 1,500 ft., *Greenway* 1974, type.

Canthium purpurascens Bullock, l.c. 368 (Rubiaceae) T.T. ; Rufiji, *Musk* 67, type.

Canthium recurvifolium Bullock, l.c. 385 (Rubiaceae) Pemba Island ; Bank of Chake Chake Creek, *Greenway* 2781, type ; Ras Mkumbuu, *Greenway* 2775.

Canthium Greenwayi Bullock, l.c. 387 (Rubiaceae) T.T. : S.E. Pares, Kisuani, 3,000 ft., altitude, *Greenway* 2179 type.

With these four new species the total number of type specimens recorded in the Amani Herbarium is now 104.

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* Colonial No. 78.

Contributions.

Sixty-seven contributions were received in the course of the year, representing a total of 3,136 specimens. They were received from the following :—

Department of Agriculture, Tanganyika Territory, communicated by the following officers :—Messrs. Allnutt (Tunduru), Bruce (Tanga), Davies (Tukuyu), Haarer (Bukoba), Harvey (Moshi), Lock (Tanga and Lushoto), Ritchie (Moshi), Rounce (Mwanza), Sanders (Moshi), Sturdy (Arusha), Wakefield (Moshi), and Wallace (Lushoto) ...	942
Department of Veterinary Science and Animal Husbandry, Tanganyika Territory, communicated by the following officers :—Messrs. Emson and Staples (mainly Njombe District) and Hornby (Njombe, Mpwapwa, and Masailand)	556
Forests Department, Tanganyika Territory *per* L. G. T. Wigg, Esq.	2
Zanzibar Museum, *per* Mrs. Taylor	27
Amani Staff	701
Royal Botanic Gardens, Kew...	838
J. Thomson, Esq., Usa River, T. T.	10
Mkoe Plantations, Ltd., Lindi, T. T.	21
F. Zimmer, Esq., Songea, T. T.	26
Miscellaneous	13
Total	3,136

Exchanges.

Specimens were exchanged and distributed with the following institutions :—

From Royal Botanic Gardens, Kew (including named East African material and named duplicates from the Thomas Sierra Leone collection) *Total received*	838
To Royal Botanic Gardens, Kew (including a collection from the Tanganyika Coffee Research Station and Mount Kilimanjaro)	1,225
Zanzibar Museum, Zanzibar	224
British Museum, London	37
Prof. E. B. Babcock, University of California, U.S.A.	1
Lyster H. Dewey, Esq., Bureau of Plant Industry, Washington, D.C., U.S.A.	3
Total distributed	1,490

Loan of Specimens.

Specimens and types were lent to :—

British Museum	91 sheets of *Combretum* spp.
Royal Botanic Gardens, Kew	58 sheets of *Pennisetum* spp.
,, ,, ,, ,,	16 sheets of Giant Lobelia.
,, ,, ,, ,,	3 sheets of Giant Senecio (returned).
,, ,, ,, ,,	29 sheets of *Canthium* spp. (returned).
Prof. E. B. Babcock, University of California, U.S.A.	7 sheets of *Crepis* spp.
A. J. Ritchie, Esq., Entomologist, Department of Agriculture, Tanganyika Territory.	22 sheets of East African Rubiaceae (returned).
N. V. Rounce, Esq., District Agricultural Officer, Department of Agriculture, Tanganyika Territory	85 sheets of Tanganyika Territory plants (returned).
Total	311 *sheets on loan or loaned.*

Field Work.

As the work in the Herbarium steadily increases less time can be spent in the field than is desirable.

Requests for botanical material and seeds of indigenous plants from private individuals and institutions engaged on research work continue to increase and the greater part of the Botanist's time could readily be occupied in the travelling and collecting necessary to meet their requirements. These requests for material are, however, fulfilled as far as possible whenever time and opportunity permit.

A single period of four weeks only was spent in the field, when on the invitation of the Department of Agriculture, Tanganyika Territory, a botanical survey was made on the site of the Department's Coffee Research Station at Lyamungo on the southern slope of Kilimanjaro, south-east and south-west of Machame and Kibosho.

The survey was carried out in August and September. Over 300 specimens were collected in the area, grid transects of the more important plant communities were mapped, and a sketch map was made of the plant communities occurring in the area. A list of Kichagga plant names together with their botanical equivalents was also compiled. A report of the survey was prepared and copies transmitted to the Director of Agriculture.

When on the southern slopes of Kilimanjaro the opportunity was taken to ascend the mountain as far as time and the terrain

permitted. An altitude of 11,500 feet was reached between the Umbwe and Weru Weru Rivers over a ridge which gradually narrowed down to a knife edge. At 10,000 feet the going became so bad for loaded porters that the final camp had to be fixed at that altitude.

On the descent over one hundred specimens were collected in triplicate, a set of which has been forwarded to the Royal Botanic Gardens, Kew, for verification. These will form a useful basis for a paper on the vegetational zones of the mountain should the opportunity occur for an ascent to their upper limits.

While descending the mountain, surface soil and shallow sub-soil samples were taken for the Soil Chemist, at every 1,000 feet from 11,500 feet down to 5,500 feet altitude, the boundary of the forest reserve.

At Lyamungo and on the mountain a collection of birds together with notes on the types of vegetation they inhabited was made for the Secretary.

Time has also been spent in the field in work on the collection of native banana varieties, and in the collection in the Amani district of plants known and used by the natives.

A start has been made collecting information with a view to an ecological survey of the East Usambaras, a work of some magnitude considering the diversity of the vegetation types and the very rugged nature of the country. Some interesting and previously unrecorded results are being obtained in connexion with plant geography and distribution.

A paper dealing with the botanical survey of the Tanganyika Territory Coffee Research Station has been submitted with a view to publication.

P. J. Greenway,
Systematic Botanist.

ORNITHOLOGICAL WORK.

Enquiries received during the year have stressed the fact that very little is on record regarding the bird-population of agricultural areas in East Africa or the inter-relations between birds and the local crops. I have brought together a certain amount of data on the subject during the last few years but only incidentally and locally. I hope that it may be possible to devote some time to a systematic investigation in future. An adequate study must deal with crops at their several stages, e.g., germination, flowering, fruiting. Moreover, the bird-population of any given area under crop is profoundly affected by the state of cultivation, e.g., clean-weeding, by the lay-out, e.g., the presence of hedges, and above all by the nature of the surrounding country. The general ecological studies that have been my main preoccupation up to the present

will help to give a sound basis for this work. Attempts to evaluate the economic relation of any particular species of bird to a particular crop will often depend ultimately on identification of the insects found in the stomachs. The prospects of adequate entomological collaboration to this end are not bright.

The detailed local survey referred to in last year's report has reached the end of its first stage. It has served an exceedingly useful purpose in emphasizing that the factors affecting bird-distribution are more obscure, complicated, and closely inter-dependent than has generally been admitted by workers in Tropical Africa. For example, temperature has been cited by some as the principal factor, rainfall by others. It does not seem to have been adequately realized that either of these factors profoundly modifies the biological potentialities of the other. Moreover, any conclusion that temperature is directly responsible for limiting bird-distribution in Tropical Africa must depend upon the assumption that birds are sensitive to comparatively slight differences in temperatures far removed from the lethal extremes. For this assumption no experimental support appears to be on record. A further important point is raised by the realization, which has escaped ornithologists generally, that many, if not most, birds, like other animals, are subjected not to the climates recorded in the usual meteorological screen three or four feet above the surface of the ground, but to the eco-climates conditioned by their specific habitats. For example, the data obtained in the undergrowth of the evergreen forest here show that the birds confined to that habitat live in a climate that has much the same minima as the "general" (screen) climate, but maxima quite 3°C. lower. On the other hand there is evidence that the eco-climate in bushes, grass, or in the open is much more extreme than the general climate, with maxima up to 5°C. higher and minima nearly as much lower. This means that birds living a few yards apart may be subjected to temperatures as different as birds separated by several degrees of latitude or thousands of feet of altitude.

Apart from specific points of which the foregoing are examples it is a fact that general ecological works have been based almost exclusively on experience in the temperate and sub-arctic zones. In some respects tropical conditions are so different that it is almost true to say that new principles are involved. Certainly new points of view are demanded. I have planned a series under the title "Contributions to Tropical African Bird-ecology," the first of which is a critical discussion of certain general problems and of criteria to be borne in mind in local ecological work. No. 2 in the series, "A Synecological Study of Usambara," has been completed.

The same close and mutually satisfactory arrangement was maintained with the British Museum (Natural History) as in previous years. The first three parts of "Taxonomic and Field-Notes on the

Birds of North-east Tanganyika Territory," in collaboration with Mr. W. L. Sclater at the Museum, have appeared in *Ibis*, 1932, pp. 487–522, 656–683; 1933, pp. 1–33. The remaining three parts have been completed.

Mention was made in my last annual report that Kilimanjaro appeared to have been somewhat neglected ornithologically. Information has since been received that the small collection made there in February, 1932, was the first received in the British Museum from that area since Sir Harry Johnston's, early in the 1880's. Apart from the intrinsic interest of Kilimanjaro its avifauna as at present recorded shows unexpected gaps. Advantage has therefore been taken of opportunities for the native collector to accompany government officers visiting the area. In this connexion I have to record my thanks to Mr. P. J. Greenway and Mr. G. Milne of this Station and Mr. E. D. Maber of the Tanganyika Forests Department. The ecological information they have given has added greatly to the value of the specimens obtained. A note on the avifauna was provided for Mr. Greenway's botanical survey of the Lyamungo Coffee Experiment Station site.

One more new form has been described from our collections :—

Muscicapidae: *Hyliota australis usambara*, Bull. B.O.C. Vol. 52, p. 104.

R. E. Moreau.

REPORT OF THE SUPERINTENDENT OF PLANTATIONS.

During the absence of the Engineer on leave the Superintendent was in charge of construction and maintenance work. On his return the Superintendent retained charge of roads, plantations, nurseries, and the Kwamkoro Coffee Estate. He also undertook the supervision of the plantation work of the Geneticist during his absence on leave.

Construction and Maintenance.

Laboratories, Offices, and Staff Quarters.

Repairs to laboratories, offices, and staff quarters have been carried out where necessary.

Numerous articles of furniture and equipment, including apparatus for the testing of sisal fibres, have been constructed in the Station workshops.

Virus Research and Plant Quarantine.

Two new greenhouses for virus research work have been completely constructed and the reinforced concrete base completed ready for the erection of the superstructure of a third.

The concrete foundations for the plant quarantine glass-houses have been built and woodwork for the superstructure of the plant reception house is practically complete.

In order to expedite the construction of the above glass-houses some additional wood-working machinery has been installed at the Kwamkoro sawmill.

All the timber required for use on the station, including the virus and plant quarantine houses, has been supplied by the Kwamkoro sawmill, *mvule* being used exclusively.

Roads.

The main Amani-Muhesa road has remained under the control of the Station, the necessary funds being supplied by the Public Works Department. General repairs and improvements have been carried out. The bridges at mile 1 and mile 3·7 from Muhesa have been decked with reinforced concrete. Existing closed culverts on the Amani-Sigi section have been converted to the open grid type. Several new culverts have been built on the Sigi-Muhesa section, making a total of over fifty of this type in all.

Certain sections which were found to cut up badly during the heavy rains have been macadamized.

Transport.

A new British Bedford 30 cwt. chassis was purchased during the year. The bodywork was constructed in the Station workshops.

The Chevrolet lorry was thoroughly reconditioned and a new body fitted. These and the six-wheeled Thornycroft have efficiently maintained the transport of the Station throughout the year.

Kwamkoro Coffee Estate.

Repairs to buildings and machinery at the Kwamkoro factory were carried out where necessary. The flume from the water furrow to the wheel had to be renewed, and new buckets fitted to the water wheel before the season's crop could be dealt with. The open-air drying sheds were repaired and a new chimney built to the drying-house furnace. The large pulper was completely overhauled.

Field work throughout the year consisted chiefly of cleaning through the plantations with bush knives, digging and mulching the ratooned *Coffea robusta* plots and the preparation of approximately 15 acres for the planting of selected *C. robusta* from Amani.

Twenty-five tons of parchment and two tons of clean coffee were shipped.

Plantations and Nurseries.

General plantation work has increased during the year. The harvesting of the whole of the cinchona bark, the draining of the swamp near the Amani-Nderema road, and the extension of many of the more important economic crops has resulted in a larger amount of native labour being employed. No difficulty, however, in obtaining labour has been experienced.

The trial plots of tung oil, *Aleurites Fordii*, are still disappointing, the plants in many cases making practically no growth. The few scattered plants mentioned in the last report have produced a few trusses of female flowers only. Two plants of *Aleurites montana* left in the original seed bed continue to do well and one is now in fruit.

The plot of *Hydnocarpus wightiana* (for chaulmoogra oil used in the cure of leprosy) is now fruiting and a quantity of seed has been collected.

A fair amount of work has been done raising plants and collecting material of plants yielding insecticides and essential oils for investigation by the Biochemist.

A succession of cover crops and green manure plants has been kept up for the supply of seed to planters and Agricultural Departments.

3,000 plants of *Casuarina equisetifolia* have been raised for road side planting on the main Amani-Muhesa road ; 8,000 *Coffea robusta* plants have been raised from seed of selected trees for planting at Kwamkoro.

Sisal.—The chief work on sisal during the year has been the extension of the plots of *Agave amaniensis* to secure planting material for eventual distribution. For this purpose a further 1,200 plants have been planted at Sigi and 1,000 at Amani. Plots of *Agave amaniensis* and *Agave sisalana* have been planted out for comparison at Sigi.

Approximately 1,000 Agave plants raised from seed obtained by crossing and self-pollination and 300 plants grown from bulbils and suckers from outside sources have been planted out for the purposes of the Geneticist.

Cacao.—Plants have been raised from seed of selected trees of Criollo cacao for filling up the plot planted up last year ; 500 plants have also been raised and planted in bamboo pots for distribution by the local Department of Agriculture.

Tobacco.—Eleven varieties of tobacco were raised from seed and approximately 100 of each planted out in the nursery for the Plant Pathologist.

Sugar Cane.—The large swamp near the Amani-Nderema road has been drained and prepared for the reception of sugar cane varieties after undergoing quarantine.

Tea.—Approximately 1,000 plants of tea have been raised from seed obtained from Ceylon and Assam and planted out for the Geneticist.

Cinchona.—The whole of the cinchona plots have now been cut. A further 134 bales of bark consisting of 42 *C. ledgeriana*, 43 *C. succirubra*, and 49 of the hybrid between the two have been prepared and despatched to England.

Coffee.—Vegetative propagation work has been continued. Further results of grafting *Coffea arabica* on ratooned *C. robusta* plants have been disappointing. An experiment in shield grafting *C. arabica* seedlings on *C. robusta* one-year-old stock has proved a failure. The result of inarching *C. arabica* seedlings on *C. robusta* seedlings, however, proved very successful. For this purpose seeds of the two species were planted in the seed beds and allowed to grow until they had produced their first pair of true leaves. One plant of each was then taken up, a strip of bark including one cotyledon was removed from the scion and the stock, and both were then fastened together with worsted. No grafting wax was used. The pairs were then planted together and allowed to grow for five weeks, when the portion of the *robusta* plant above the union was removed. A week later the *arabica* stem below the union was cut half through and at the end of the following week cut through completely. Practically 100 per cent. of growing plants were obtained, and it would appear that this method of inarching seedlings will be extremely useful where seed of suitable stocks and scions is available.

Plant and Seed Introduction.

27 packets of seeds.
1 lb. *Elettaria cardamomum.*
5 lb. *Milletia oblata.*
52 plants (miscellaneous).
173 suckers *Agave cantala.*
15 cuttings (miscellaneous).
5 packets Tubers of *Ipomoea batatas.*

Plant and Seed Distribution.

400 packets of seeds.
33 lb. Coffee seed.
258 lb. of miscellaneous seeds, including cover-crops and temporary shade trees.
299 individual and 8 boxes of miscellaneous plants.
20 lb. Ginger rhizomes.
6 lb. *Boehmeria nivea* rhizomes.
6 lb. *Cymbopogon citratus* roots.
906 cuttings.

F. M. Rogers,
Superintendent of Plantations.

REPORT OF THE SECRETARY AND LIBRARIAN.

The Assistant Secretary was absent on leave until the beginning of November.

The work of the office calls for no comment except to observe that there has been a continually increasing pressure of typing work. This is due partly to the fact that so much of the scientific work is reaching the stage of report and publication, and partly to the labour connected with the maintenance of the classified subject index for the Library. I anticipate difficulty when the Stenographer is on leave this year.

There can be no question that the index justifies itself. Apart from its constant use for normal reference it has enabled me to supply bibliographies, e.g., on the subject of drought-fodders, practically by return of post.

One major piece of translation has been carried out during the year, *Das Klima der Bodennahen Luftschicht* (Geiger, Braunschweig). It was prepared primarily in connexion with the Entomologist's investigations into the ecology of coffee insects ; but the subject of eco-climates is one whose importance is increasingly realized in many branches of ecology and their agricultural applications. Typescript copies of the translation are available for loan.

Fifty-nine books, a large number of pamphlets, and several long series of periodicals have been added to the Library during the year. A list of periodical series additional to that given in last year's Report appears in Appendix B. Particular attention may be drawn to the fine series of the important Dutch East Indian publications that have been built up with the generous assistance of the Dutch authorities.

R. E. Moreau,
Secretary and Librarian.

APPENDIX A.

FINANCIAL STATEMENT FOR THE NINE MONTHS ENDED 31st DECEMBER, 1932.*

Revenue.

	£	£
Ordinary Recurrent Revenue :—		
Contribution, Empire Marketing Board	4,500	
,, Tanganyika Territory	4,500	
,, Uganda	1,350	
,, Kenya	1,275	
,, Zanzibar	900	
,, Northern Rhodesia	225	
,, Nyasaland	225	
	12,975	
Local Revenue	249	
	13,224	
Extraordinary Revenue :—		
Levy on Salaries	495	
Sale of Cinchona Bark	1,205	
		£14,924

Expenditure.

	£	£
Personal Emoluments	8,165	
Passages	450	
Pensions Contributions	1,447	
Laboratories	734	
Library and Publications	171	
Office, Telephones, Contingencies	153	
Materials	395	
Freight and Transport	549	
Travelling	496	
Labour	936	
		13,496

Summary.

	£	£
Recurrent Revenue		13,224
Extraordinary Revenue		1,700
Total Assets		14,924
Debit Balance on 1st April, 1932	116	
Expenditure (nine months)	13,496	
Total Liabilities		13,612
Credit Balance on 31st December, 1932		£1,312

Note :—This credit balance has to meet a liability of £274 for cost of passages carried forward from 1932 to 1933 in accordance with the leave programme. Part of the remainder is earmarked for grants in aid of publications.

* Conforming to the change made by the Tanganyika Government in the date of commencement of the financial year.

Kwamkoro Coffee Estate.

	£	£
REVENUE		
Sale of Coffee		637
EXPENDITURE.		
Crop Expenses:—	£	
Labour	215	
Materials	34	
Freight and Transport	231	
	480	
Other Expenses:—		
Labour	217	
		697
Excess of Expenditure over Revenue actually encashed... ...		£60*

APPENDIX B.

LIST OF IMPORTANT PERIODICAL SERIES ADDITIONAL TO THOSE DETAILED IN THE FOURTH ANNUAL REPORT.

(*As before, Colonial Agricultural Department Publications, of which we have full series, are not specified.*)

Australia—

Queensland Agricultural Journal.
Agricultural Gazette of New South Wales.

Belgium—

Bulletin du Jardin Botanique de l'Etat.

Dutch Indies—

Among the numerous series special attention may be drawn to the following :—
Archief voor Cacao en andere kleine cultures.
Archief voor de Theecultuur.
Archief voor de Koffiecultuur (on order).
Instituut voor Plantenziekten—Mededeelingen.
Mededeelingen van het Proefstation Vorstenlandsche Tabak.
Mededeelingen s'Lands Plantentuin.
Mededeelingen Proefstation voor Thee.
Natuurkundig Tijdschrift van Nederlandsch Indie.

Germany—

Feddes Repertorium Novarum Speciarum Regni Vegetalis.
Mitteilungen der Deutschen Entomologischen Gesellschaft.
Notizblatt des Botanischen Gartens und Museum zu Berlin.
Zeitschrift für Pflanzenernahrung Düngung und Bodenkunde.

Holland—

Resumptio Genetica.

* This is covered by the proceeds from the remainder of the 1932 crop, approximately £800 net, marketed since 31st December, 1932.

India—

Indian Tea Association Scientific Papers.
Journal of the Indian Institute of Science.
Mysore Coffee Experiment Station Bulletins.
Mysore Department of Agriculture Bulletin Series.
Bombay Department of Agriculture Bulletins.

'Iraq—

Department of Agriculture Bulletins and Memoirs.

Italy—

Lavori del R. Istituto Botanico di Palermo.

Philippines—

Philippine Journal of Agriculture.

Porto Rico—

Department of Agriculture Journal.

United Kingdom—

Biochemical Journal.
Reports of the British Association for the Advancement of Science.

United States of America—

Bulletins and Memoirs, New York Botanical Gardens.
Contributions from the United States National Herbarium.
Industrial and Engineering Chemistry—Analytical Edition.
Physiological Reviews.

(19874—28) Wt. P981—3045 1125 7/33 P.St. G.7/8

EMPIRE MARKETING BOARD PUBLICATIONS

Note on the work of the Board and Statement of Research and other Grants approved by the Secretary of State from July, 1926, to March, 1932. Cmd. 4121. 9*d.* (10*d.*).

British Empire Hardwoods from the point of view of Turnery. 2*s.* (2*s.* 2*d.*).

Wool Quality: A Study of the Influence of various contributory factors, their significance and the technique of their measurement. Cloth. £1 1*s.* (£1 1*s.* 9*d.*).

Australian and New Zealand Fruit Shipments. Report of an investigation into the deterioration in transit of Imported Australian and New Zealand Fruit, 1927–30. (E.M.B. 46.) 1*s.* (1*s.* 2*d.*).

Banana Breeding at the Imperial College of Tropical Agriculture. (E.M.B. 47.) 1*s.* (1*s.* 2*d.*).

Imperial Sugar Cane Research Conference, 1931. Report of Proceedings. 2*s.* 6*d.* (2*s.* 11*d.*).

Further Changes in the Demand for Butter, July, 1928, and July, 1931. Report of an Investigation into the Retail Marketing of Butter in Nottingham. (E.M.B. 48.) 1*s.* (1*s.* 1*d.*).

Fruit Supplies in 1931. (E.M.B. 49). 1*s.* (1*s.* 3*d.*).

The Demand for Honey. (E.M.B. 50.) 1*s.* (1*s.* 2*d.*).

Milk Price Margins. A Report on the Differences between Producers' Prices, Wholesale Prices and Retail Prices of Liquid Milk in certain Large Cities in Different Countries. (E.M.B. 51.) 1*s.* (1*s.* 2*d.*).

Dairy Produce Supplies in 1931. (E.M.B. 52.) 1*s.* (1*s.* 3*d.*).

Survey of Vegetable Oilseeds and Oils. Vol. I. Oil Palm Products. (E.M.B. 54.) 1*s.* (1*s.* 4*d.*).

Canned and Dried Fruit Supplies in 1931. (E.M.B. 55.) 1*s.* (1*s.* 3*d.*).

The Demand for Canned Vegetables. (E.M.B. 56.) 1*s.* (1*s.* 1*d.*).

Wool Survey. A Summary of Production and Trade in the Empire and Foreign Countries. (E.M.B. 57.) 2*s.* (2*s.* 6*d.*).

Cattle Breeding in Jamaica and Trinidad. (E.M.B. 58.) 1*s.* (1*s.* 2*d.*).

The Storage of Tropically-grown Tomatoes. (E.M.B. 59.) 1*s.* (1*s.* 2*d.*).

Control of Wastage in Bananas, with special reference to Time and Temperature Factors. (E.M.B. 60.) 1*s.* (1*s.* 4*d.*).

Survey of Oilseeds and Vegetable Oils. Vol. II. Coconut Palm Products. (E.M.B. 61.) 2*s.* (2*s.* 5*d.*).

Barley Survey. A Study of Barley Production, Exports, Imports, Marketing, Markets and Prices in the Principal Exporting and Importing Countries in the World. (E.M.B. 62.) 2*s.* (2*s.* 5*d.*).

Empire Marketing Board. May, 1932, to May, 1933. (E.M.B. 63.) 1*s.* (1*s.* 3*d.*).

Sisal: A note on the Attributes of the Fibre and their Industrial Significance. (E.M.B. 64.) 1*s.* (1*s.* 3*d.*).

Fruit Supplies in 1932. (E.M.B. 65.) 1*s.* (1*s.* 3*d.*).

Dairy Produce Supplies in 1932. (E.M.B. 66.) 1*s.* (1*s.* 3*d.*).

Report on the Infestation of Cured Tobacco in London by the Cacao Moth Ephestia Elutella H.B. (E.M.B. 67.) 1*s.* (1*s.* 3*d.*).

Palestine Orange Shipments. (E.M.B. 68.) 1*s.* (1*s.* 2*d.*).

Canned and Dried Fruit Supplies in 1932. (E.M.B. 69.) 1*s.* (1*s.* 4*d.*).

All prices are net. Those in brackets include Postage.

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